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Agricultural Sciences

SUSTAINABLE LAND USE AND CROP PRODUCTIVITY IN SEMI-ARID FARMING SYSTEMS: SOIL MANAGEMENT AND YIELD STABILITY

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Semi-arid farming systems are characterized by limited and highly variable precipitation, elevated evapotranspiration, and frequent exposure to climatic stressors that constrain agricultural productivity. In such environments, sustainable land use practices are not merely desirable but essential for maintaining crop productivity and long-term soil fertility. The interaction between soil management strategies and yield stability determines the resilience of agricultural systems and their capacity to support food security under conditions of climatic uncertainty. This thesis examines how sustainable land use approaches influence crop productivity in semi-arid regions, with particular attention to soil management practices that enhance yield stability over time.

Land use sustainability in semi-arid agriculture is closely linked to soil quality, which functions as the primary medium for water retention, nutrient cycling, and root development. Soils in these regions often exhibit low organic matter content, weak structural stability, and susceptibility to erosion. Unsustainable land use practices, including excessive tillage and monocropping, exacerbate soil degradation and reduce the capacity of agroecosystems to buffer climatic variability. As a result, yield fluctuations increase, undermining both economic viability and environmental integrity.

Soil management practices aimed at sustainability focus on preserving soil structure, enhancing organic matter accumulation, and improving water use efficiency. Conservation tillage, crop residue retention, and diversified crop rotations are among the most widely adopted strategies. These practices reduce soil disturbance, protect the surface from erosion, and promote biological activity. Enhanced soil organic matter improves aggregate stability and increases the soil's capacity to retain moisture, which is particularly critical during periods of drought.

Crop productivity in semi-arid systems depends not only on average yields but also on yield stability across seasons. High yields in favorable years do not compensate for severe losses during drought years, as variability introduces economic risk and threatens food supply continuity. Yield stability is therefore a key indicator of sustainable land use performance. Practices that moderate the impact of rainfall variability and temperature extremes contribute to more predictable production outcomes.

The relationship between soil management and yield stability is mediated by water availability. In semi-arid regions, precipitation is often insufficient to meet crop water requirements, making efficient water capture and storage within the soil profile a primary objective. Improved soil structure enhances infiltration rates and reduces runoff, allowing a greater proportion of rainfall to be stored in the root zone. Mulching with crop residues reduces surface evaporation and moderates soil temperature, further conserving moisture.

Table 1 presents a comparative overview of common soil management practices in semi-arid farming systems and their primary agronomic effects.

Table 1. Soil Management Practices and Their Agronomic Effects in Semi-Arid Farming Systems

Soil management practice	Primary effect on soil	Implication for crop productivity
Conservation tillage	Reduced soil disturbance	Improved moisture retention
Crop residue retention	Surface protection	Reduced evaporation and erosion
Crop rotation	Enhanced biological activity	Improved nutrient availability
Organic amendments	Increased organic matter	Greater yield stability

Beyond soil physical properties, sustainable land use also influences nutrient dynamics. In degraded soils, nutrient availability is often constrained by low organic matter and reduced microbial activity. Sustainable soil management enhances nutrient cycling by supporting diverse soil biota, which facilitate the mineralization of organic residues and improve nutrient uptake efficiency. This biological dimension of soil fertility is particularly important in semi-arid environments, where chemical inputs alone may be insufficient or economically unviable.

Crop selection and diversification further contribute to sustainable land use outcomes. Crops with deep or extensive root systems improve soil structure and access water from deeper layers, enhancing drought tolerance. Including legumes in rotations contributes to biological nitrogen fixation, reducing dependence on external inputs and improving soil fertility over time. Diversification also reduces pest and disease pressure, contributing indirectly to yield stability.

Economic considerations play a critical role in the adoption of sustainable land use practices. Farmers operating in semi-arid regions often face narrow profit margins and high production risks. Sustainable practices that reduce input costs and stabilize yields improve economic resilience. Although some practices may require initial investment or changes in management routines, long-term benefits include reduced soil degradation, lower input dependency, and more consistent production.

Yield stability is influenced by both environmental and management factors. While climatic variability cannot be controlled, its effects can be mitigated through adaptive land use strategies. Soils with higher organic matter content exhibit greater buffering capacity against moisture stress, leading to less pronounced yield reductions during drought periods. Similarly, diversified cropping systems distribute risk across multiple

crops, reducing the impact of adverse conditions on total farm output.

Table 2 summarizes key indicators of yield stability in relation to soil management intensity in semi-arid agriculture.

Table 2. Yield Stability Indicators in Relation to Soil Management Intensity

Soil management intensity	Yield variability over time	Resilience to drought conditions
Low (conventional)	High	Limited
Moderate (partial conservation)	Moderate	Improved
High (integrated sustainable practices)	Low	High

Sustainable land use also has broader environmental implications. Reduced soil erosion protects downstream ecosystems and maintains land productivity. Improved soil carbon sequestration contributes to climate mitigation efforts while enhancing soil fertility. These co-benefits reinforce the value of sustainable practices beyond immediate yield outcomes.

The social dimension of sustainable land use should not be overlooked. Knowledge transfer, farmer education, and access to advisory services influence the successful implementation of soil management strategies. Adoption rates increase when farmers understand the long-term benefits and receive practical guidance tailored to local conditions. Community-based approaches facilitate shared learning and collective action, enhancing regional sustainability outcomes.

Challenges to sustainable land use in semi-arid regions include limited access to resources, short-term economic pressures, and institutional constraints. Policies that support sustainable practices through incentives, extension services, and risk mitigation mechanisms enhance adoption and effectiveness. Aligning policy objectives with environmental and productivity goals is essential for long-term success.

In conclusion, sustainable land use in semi-arid farming systems is a critical determinant of crop productivity and yield stability. Soil management practices that enhance organic matter, improve water retention, and support biological activity contribute to resilient agroecosystems capable of withstanding climatic variability. Yield stability emerges as a central outcome of sustainability, reflecting the capacity of agricultural systems to deliver consistent production under challenging conditions. Integrating sustainable soil management with diversified cropping and supportive institutional frameworks provides a viable pathway for enhancing productivity, economic resilience, and environmental sustainability in semi-arid agriculture.

Keywords: *Sustainable land use; Semi-arid agriculture; Soil management; Crop productivity; Yield stability; Agroecosystem resilience*

Cultural Sciences

"THE OPENING OF THE FOUR PALACES (TỨ PHỦ)" RITUAL IN THE SPIRIT MEDIUMSHIP CEREMONY OF THE MOTHER GODDESS WORSHIP TRADITION IN DA NANG AND NORTHERN VIETNAM

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Abstract

The article focuses on researching The Opening of the Four Palaces ceremony of the Mother Goddess Worship Tradition in Da Nang and Northern Vietnam. In this article, the author uses two main research methods of of belief culture, methods from cultural studies and anthropology are widely used because they help us understand belief as a living phenomenon, closely connected to people, communities, and the social context.

The spirit mediumship ritual (hầu đồng) comprises numerous ceremonial segments, procedures, scales of organization, and timings, which vary from place to place and carry distinct symbolic meanings. The hầu đồng ritual consists of four principal ceremonial segments annually, conducted by temple mediums on behalf of devotees and disciples. Within the spirit mediumship practices of the Mother Goddess Worship tradition, the Opening of the Four Palaces (lễ mở phủ – Tứ Phủ) holds a particularly significant role for spirit mediums (thanh đồng), the general term for individuals who perform spirit possession rituals.

The Opening of the Four Palaces ceremony is typically held during the ritual periods of the third and eighth lunar months-expressed in the traditional saying, "the eighth month is the Father's festival, the third month is the Mother's festival"-and takes place at local temples as well as in private residences. This article examines several distinctive features of the Opening of the Four Palaces ceremony within spirit possession rituals as practiced in Da Nang and Northern Vietnam.

1.Introduction

The study of the Mother Worship belief in general has seen many notable works, including: Nhất Lang (1962), *Đồng bóng*, Le Cuong Printing House, Hanoi; Nguyễn Ngọc Mai (2013), *Rituals of Spirit Mediumship: History and Value*, Cultural and Information Publishing House, Hanoi; Ngô Đức Thịnh (2004), *The Mother Religion and Shamanic Practices in Vietnam and Asia*, Social Sciences Publishing House, Hanoi; Ngô Đức Thịnh (2009), *Vietnamese Mother Religion, Volume 1*, Religion Publishing House, Hanoi... These works provide a comprehensive view of the Mother Religion in Vietnam. However, there has been no research on the Mother Worship belief in Da Nang until now. Therefore, using statistical, analytical, comparative methods, and especially fieldwork (in-depth interviews), this paper aims to systematically portray the Mother Worship belief in Da Nang, analyze the distinctive features of this belief in the region, and supplement materials for the research and teaching of religious beliefs in general, and Mother Worship in particular. This will help promote and preserve a beautiful belief recognized by UNESCO as an Intangible Cultural Heritage of Humanity.

The *hầu đồng* ritual comprises four principal ceremonial cycles: the *Hầu Thượng Nguyên* (Upper Primordial Ceremony), the *Hầu Nhập Hạ* (Entering Summer Ceremony), the *Tán Hạ* Ceremony, and the *Tất Niên* (Year-End Ceremony). In addition, depending on each temple or each *ông Đồng* or *bà Đồng* (collectively referred to as *thanh đồng*, spirit mediums), the occasions for spirit possession rituals may be far more numerous.

For newly initiated spirit mediums, the first ritual is the *lễ trình đồng*, which serves as an introductory rite enabling the medium to become acquainted with the Mother Goddess belief system (*Đạo Mẫu*). In cases where the novice medium lacks sufficient financial means to organize a formal *lễ trình đồng*, a simpler offering consisting of betel leaves and areca nuts—known as a *mâm trầu trình*—may be prepared and presented to the Holy Mother (*Thánh Mẫu*). During this rite, the officiating master (*đồng thầy*) covers the medium with a ritual cloth and instructs them to carry the offering tray.

Three years after the *lễ trình đồng*, the medium performs the *Mở Phủ* ceremony of the *Tứ Phủ* (Four Palaces), comprising the Heavenly Palace (*Thiên Phủ*), the Mountain and Forest Palace (*Nhạc Phủ*), the Water Palace (*Thủy Phủ*), and the Earth Palace (*Địa Phủ*). Following another three-year period, the *lễ tạ* (thanksgiving ceremony) is conducted. This rite expresses gratitude to the deities and determines whether the medium is qualified to become a "thầy"-that is, a ritual master who presides over spirit possession ceremonies and guides new mediums within the Mother Goddess tradition.

Beyond these formal rites, there are also festive *hầu đồng* occasions, such as the Feast of Lady Cô Bơ (the 12th day of the 6th lunar month), the Feast of Mother Goddess of the Highlands (*Mẫu Thượng Ngàn*, the 9th day of the 9th lunar month), the Feast of Prince Quan Hoàng Mười (the 10th day of the 10th lunar month), and the Feast of Prince Quan Đệ Nhị (the 11th day of the 11th lunar month).

Each *hầu đồng* ceremony consists of two main components: the ritual segment (*phần lễ*) and the festive or performative segment (*phần hội*), which involves the enactment of various spirit incarnations (*giá đồng*). Depending on the specific ceremony, the relative emphasis placed on these two components may vary. The *Mở Phủ* ritual is particularly significant, as it marks the official recognition of the *thanh đồng* as a devoted disciple of the Holy Mother. Consequently, the ritual segment is conducted with great solemnity and serves to formally announce the purpose of the ceremony to the deities of the Four Palaces and the collective spirits of the temple.

Within the cosmology of the *Tứ Phủ*, hierarchical order is strictly observed. The Holy Mother is invoked first, followed by the ten Mandarins (*Quan*), the Court Ladies (*Chầu* or *Chúa*), the Princes (*Ông Hoàng*-ten figures revered for their combined civil and martial virtues), the Holy Maidens (*Cô*, numbering twelve and named sequentially from the First Maiden to the Twelfth, known as *Cô Bé*), and finally the Holy Youths (*Cậu*, comprising ten deities).

Regarding the festive segment, the *Mở Phủ* ceremony is

regarded as the most important event within the *hầu đồng* tradition. Therefore, spirit mediums receive meticulous guidance from their ritual masters prior to ascending the ritual mat (*chiếu hầu*). Each medium is required to continuously recite a prayer invoking the Holy Mother, beseeching her to grant them a graceful and dignified possession—expressed in the phrase "*hầu sang, đồng ngoan, bóng sang, bóng lịch sự*," meaning that the enactment of spirit incarnations should be aesthetically refined, respectful in speech, and elegant in movement. It is believed that performing the ritual beautifully and with dignity will bring greater fortune and happiness in life. The festive segment of the *Mở Phủ* ceremony typically occupies nearly an entire day, during which a medium may enact between twelve and eighteen spirit incarnations.

2. Materials

"The *Mở Phủ* Ceremony" in the *Hầu Đồng* Ritual of the Mother Goddess Worship in Da Nang and Northern Vietnam

In Northern Vietnam, the form of Mother Goddess worship is characterized by the veneration of the Three and Four Palaces (*Tam Phủ* and *Tứ Phủ*). This system represents the development of three successive and organically interconnected layers: "female deities, mother goddesses, and the Mother Goddesses of the Three and Four Palaces" (Ngô Đức Thịnh 2009, *Vietnamese Mother Goddess Religion*, vol. 1, Religious Publishing House, Hanoi, p. 38). Building upon the indigenous worship of female and mother deities, this belief system "incorporates influences from Chinese Daoist cosmological concepts and pantheons" (Ngô Đức Thịnh 2009, *Vietnamese Mother Goddess Religion*, vol. 1, Religious Publishing House, Hanoi, p. 39).

In Da Nang, this region can be regarded as a typical site of cultural syncretism between Northern Vietnamese Mother Goddess worship and that of the South Central region. The fundamental characteristic of this local form lies in the presence of the Three and Four Palaces system, while simultaneously bearing distinct regional features. Notably, within the pantheon—especially regarding the principal deity-the central figure is not Liễu Hạnh, as commonly found in Northern Vietnam, but Thiên Y A Na. Nevertheless, "the attire of the principal deity in the temples and shrines here closely resembles that of the principal deity in Northern Vietnam" (Đinh Thị Kim Ngân 2022, "Mother Goddess Worship in Da Nang," *Journal of Central Region Social Sciences*, no. 1, p. 51).

2.1. Ritual Practices

In Northern Vietnam, in order to open the Three or Four Palaces (*Tam/Tứ phủ*), a spirit medium (*thanh đồng*) must perform two rituals known as the *yin* and *yang* rites.

The *yin* rite lasts an entire day and aims to sever karmic burdens accumulated by the lineage over many generations, liberate souls believed to be bound in the underworld, and present offerings to ancestral lineages. These offerings include paper houses, spirit money, gold and silver paper, clothing, and other votive items. This rite is presided over by a senior Buddhist monk, who chants sutras continuously throughout the day, while the medium and family members sit below the ritual altar to listen to the recitation.

The *yang* rite refers to the formal ritual of opening the palaces through spirit possession (*lên đồng*). This ceremony is usually conducted in the morning. Prior to the main ritual, a ritual master chants invocations to invite ancestral spirits, and an offering tray for wandering souls is placed in front of the temple courtyard. After the chanting is completed, the palace-opening ceremony begins. The medium's master conducts possession rituals for the Three Holy Mother Thrones (*Tam Tòa Thánh Mẫu*)-without covering the face with a veil-and then successively incarnates four Mandarins to carry out the procedures of establishing the altar and opening the palaces: the First Mandarin of the Heavenly Realm (*Quan Đệ Nhất Thượng Thiên*), the Second Mandarin, the Third Mandarin, and the Fourth Mandarin. Finally, the Fifth Mandarin Tuần Tranh is invoked to disperse and conclude the ritual assembly. Each mandarin is associated with distinct ritual costumes.

When the First Mandarin of the Heavenly Realm descends, he wears a red robe embroidered with dragons and tiger talismans and performs incense-offering rites, consecration, validation of petitions and votive documents, and certification of the opening of the Heavenly Palace. The Second Mandarin, when incarnated, wears green garments with a green sash, embroidered with dragons and tiger talismans, along with green accessories. He performs incense-offering, consecration, validation of petitions, sword dances, seated rites, and wine offerings, certifying the opening of the Mountain and Forest Palace (*Nhạc phủ*). The Third Mandarin, dressed in a white robe embroidered with dragons and tiger talismans, conducts incense-offering, consecration, validation of petitions, and opens the Water Palace (*Thoải phủ*). The Fourth Mandarin wears a yellow robe, a ceremonial turban decorated with gilded patterns, and a golden command talisman; upon incarnation, he performs incense-offering, consecration, and opens the Earth Palace (*Địa phủ*) (In-depth interview, Ms. Trần Thị T., Đền Thượng, Phủ Giầy, Nam Định, 20 March 2022).

The Fifth Mandarin Tuần Tranh wears a blue robe embroidered with dragons and tiger talismans. He performs incense-offering, consecration, validation of petitions to disperse the altar, followed by a ritual dance with the Green Dragon halberd to formally conclude the ceremony. Each mandarin conducts a palace-opening rite for the medium. The offerings for the opening ritual include four potted plants, gold and silver votive paper, and four sealed jars of water. The mouths of the jars are marked with different colors symbolizing the Four Palaces: red for the Heavenly Palace, green for the Mountain Palace, white for the Water Palace, and yellow for the Earth Palace. After completing the Mother Goddess rituals, the mandarins symbolically "open" the intellect, hearing, sight, and heart of the medium using torches. The next step involves piercing the mouths of the jars (wrapped in paper) with a sword, symbolizing the opening of the palaces. Each mandarin opens one palace; however, the Fifth Mandarin Tuần Tranh plays the most crucial role in dispersing the ritual assembly, as votive objects and petitions may only be burned after he descends to witness the ceremony (In-depth interview, Mr. K., Communal Temple, Phủ Dầy, Nam Định, 20 March 2022).

An indispensable offering in the palace-opening ritual is the *ngân khố* (ritual treasury) used to repay debts to the celestial officials (*Tào quan*), which are believed to have been incurred by the medium in a previous life. The amount paid depends on the age of the medium. Another essential offering is the *Động Sơn Trang*, consisting of paper effigies of the Second Mother Goddess of the Mountain Realm and 24 Mountain Maidens. In addition, paper elephants, horses, and various other votive objects are offered to the Holy Mothers, mandarins, and attendant spirits. In Northern Vietnam, palace-opening rituals are typically held at local temples. The cost of such ceremonies can amount to hundreds of millions of Vietnamese đồng (In-depth interview, Mr. T., Đền Mẫu Nghi Thiên Hạ, Phủ Dầy, Nam Định, 20 March 2022).

In Đà Nẵng

Prior to performing the palace-opening ritual, the spirit medium (*thanh đồng*) works with the temple owner to prepare two

offering trays: one for wandering spirits (*chúng sinh*) and one for the deities (*Thánh*). The offering for wandering spirits is arranged on a tray containing votive paper cut into the shapes of clothing and money, gold leaves, silver ingots, bowls of porridge, cakes, fruits, and other foods. In some cases, several coins are placed in a basin of water intended for the souls of those who drowned. Offerings to the deities consist of food and various fruits and cakes; however, this ritual obligatorily includes three types of meat (*tam sinh*): chicken, duck, and pork. After the offerings are completed, votive paper is burned for the wandering spirits and the deities of the Four Palaces, and the ashes are scattered around the temple.

Unlike in Northern Vietnam, the *yin–yang* ritual sequence is not practiced in Đà Nẵng; only the *yang* rite, namely the spirit possession ritual, is performed. The palace-opening ceremony takes place in the morning and concludes at approximately 7:00 p.m. on the same day. Prior to the ritual, there is no Buddhist chanting by a ritual specialist as in the North; instead, the ceremony is conducted directly by the medium's ritual master. The ritual begins with the incarnation of the Three Holy Mother Thrones (*Tam Tòa Thánh Mẫu*), followed by the possession of four mandarins who descend to witness the altar and conduct the opening of the Four Palaces.

Due to processes of Việt-Chăm cultural acculturation and the historical southward expansion of Đại Việt Kingdom, from Đà Nẵng southward there are no figures referred to as the "First Prince" or "Eldest Prince." In Đà Nẵng, the Second Prince holds a status equivalent to that of the First Prince in Northern Vietnam. Consequently, the pantheon of the Mother Goddess religion in Đà Nẵng does not include a First Mandarin; instead, the Second Mandarin occupies the highest rank among the mandarins. The four mandarins who descend to witness the palace-opening ritual bear different titles from those in Northern Vietnam, namely: the Second Mandarin of the Heavenly Realm (*Quan Đệ Nhị Thượng Thiên*), the Second Mandarin of the Mountain Realm (*Quan Đệ Nhị Thượng Ngàn*), the Third Mandarin Inspector (*Quan Đệ Tam Giám Sát*), and the Fifth Mandarin Tuần Tranh (*Quan Đệ Ngũ Tuần Tranh*). Each mandarin wears distinctive ritual attire: the Second Mandarin of the Heavenly Realm in red, the Second Mandarin of the Mountain Realm in green, the Third Mandarin Inspector in white, and the Fifth Mandarin Tuần Tranh in attire similar to that worn in Northern Vietnam.

Unlike in the North, the palace-opening ritual in Đà Nẵng does not involve four water jars or potted plants. The mandarins who descend to establish the altar and open the palaces typically use torches to symbolically illuminate and empower the medium, approve ritual petitions, and certify the ceremony (In-depth interview, owner of Tam Thánh Điển Temple, medium H., Đà Nẵng, 20 July 2022).

Offerings for the palace-opening ritual in Đà Nẵng do not include a ritual treasury (*ngân khố*) for repaying debts to celestial officials (*Tào quan*), as is customary in Northern Vietnam. Palace-opening rituals (of the Four Palaces) in Đà Nẵng are more commonly held at private household shrines dedicated to the Mother Goddesses rather than at communal temples or public shrines. The cost of a palace-opening ritual typically ranges from 40 to 100 million Vietnamese đồng (In-depth interview, owner of Bồ Tát Điện Shrine, Mr. Th., Đà Nẵng, 22 July 2022).

2.2. Festive Component (Performance of Spirit Possession Rituals)

2.2.1. Costumes and Sequence of Spirit Possession Incarnations

Costumes

Prior to a spirit possession ceremony, spirit mediums (*thanh đồng*) carefully fold the costumes for each incarnation (*giá hầu*) and store them in a separate suitcase. As Ngô Đức Thịnh observes, "Some affluent male or female mediums acquire different sets of costumes: luxurious ones reserved for their home temples and major festivals, and other sets used during pilgrimages or when performing rituals at temples in other localities" (Ngô Đức Thịnh, 2009, *Đạo Mẫu Việt Nam*, vol. 1, Religious Publishing House, Hanoi, p. 83). Each incarnation corresponds to a specific deity and therefore requires a distinct costume; costumes are not interchangeable. In a single ritual session, the medium must prepare costumes for all incarnations to be performed.

In Đà Nẵng, apart from the costumes for incarnations such as the Second, Third, and Fourth Mandarins, the Fifth Mandarin Tuần Tranh, Prince Bảy, and Prince Mười, most ritual costumes differ markedly from those used in Northern Vietnam. These include the costumes of the Mountain Lord (*Chúa Thượng Ngàn*), the Ninth Mountain Lady (*Cô Chín Thượng Ngàn*), the Ninth Mountain Lord (*Ông Chín Thượng Ngàn*), Lady Bơ of the Water Palace (*Cô Bơ Thoải Phủ*), as well as female deities such as the White Third Princess (*Bạch Ba Công Chúa*) and male deities such as the Second Sacred Prince (*Cậu Hai Tôn Thần*) and the Third Inspector Prince (*Cậu Ba Giám Sát*). Due to strong local characteristics, the names of these incarnations do not appear in the Northern Vietnamese pantheon, and their costumes likewise reflect local cultural influences.

For example, in Northern Vietnam, the Ninth Mountain Lady typically wears a black robe embroidered with dragons and phoenixes, a wrapped skirt, a black sash, and blue shoes. In contrast, in Đà Nẵng she wears attire resembling that of a H'Mông woman, including a headscarf, a side-fastened blouse, a skirt, and blue shoes (In-depth interview, Head Custodian of Tam Giang Thánh Điện, Mr. T. V. H., Đà Nẵng, 25 July 2022).

Sequence of Incarnations

In Northern Vietnam, the ritual sequence begins with the invocation of the Three Holy Mother Thrones (*Tam Tòa Thánh Mẫu*), during which the medium listens to the ritual music without unveiling the face. This is followed by the incarnations of the Ten Mandarins, the Twelve Ladies of the Court (*Thánh Hàng Chầu*), the Ten Princes from the First Prince to the Tenth Prince, the Twelve Ladies (*Cô*) from the First Lady (*Cô Cả*) to the Youngest Lady (*Cô Bé*), the Ten Sacred Princes (*Thánh Cậu*), and finally the invocation of ancestral female spirits (*bà tổ cô*), young female spirits (*cô nường*), and young male spirits (*ông mãnh*), who are believed to have died prematurely (In-depth interview, Mr. B., Temple of the First Mandarin of the Heavenly Realm, Thái Bình, 20 March 2022).

In Đà Nẵng, the ritual sequence begins with the invocation of the Three Holy Mother Thrones, followed by the incarnation of the Tutelary Lady (*Bà Quan Thầy*), the founder of the temple or shrine. Next are the four Mandarins: the Second Mandarin of the Heavenly Realm, the Second Mandarin of the Mountain Realm, the Third Inspector Mandarin, and the Fifth Mandarin Tuần Tranh. These are followed by the female deities (*các bà*), regarded as daughters of the Jade Emperor, including the White Third Princess; the Mountain Lord (*Chúa Thượng Ngàn*); Ông Đốc (the ferryman figure); and the Princes (*Cậu*), also considered sons of the Jade Emperor, namely the Second Sacred Prince, the Third Inspector Prince, the Sixth Prince of the Outer Heaven (*Cậu Lục Ngoại Càn*), and the Seventh Prince of Champa origin (*Cậu Bảy Chiêm Thành*).

In Đà Nẵng, the incarnations of the Princes are adult figures

rather than the Ten Child Princes commonly venerated in Northern Vietnam. This is followed by the incarnations of three Princes-Prince Bơ, Prince Bảy, and Prince Mười-and the Ladies (*Cô*), including Cô Ba Ngoại, Cô Bá Thủy, Cô Bơ, Cô Chín Thượng Ngàn, and Cô Chín Giếng. The ritual concludes with the incarnation of *bà tổ cô*. In Đà Nẵng, mediums are permitted to incarnate *bà tổ cô*, remove the ritual veil, communicate directly with descendants, and deliver judgments. In contrast, in Northern Vietnam, mediums are not allowed to incarnate *bà tổ cô*; they may only symbolically invoke her presence by covering the head with a ritual veil while listening to the chant, without unveiling or engaging in direct communication (In-depth interview, owner of Tam Thánh Điển Temple, medium H., Đà Nẵng, 20 July 2022).

2.2.2. Ritual Attendants (*Hầu dâng*) and Ritual Musicians (*Cung văn*)

Ritual Attendants (*Hầu dâng*)

Ritual attendants are usually individuals who have previously served as spirit mediums or have participated in spirit possession ceremonies in order to learn from more experienced attendants. They assist the *thanh đồng* during the ritual by performing various tasks, such as lighting incense and presenting ritual weapons, tobacco, alcohol, beer, betel, and other offerings. Typically, two attendants sit on either side of the ritual platform, wearing traditional *áo bà ba* shirts and silk trousers.

In Northern Vietnam, the two attendants are responsible for preparing and dressing the medium directly on the ritual mat, including costumes, footwear, headgear, sashes, jewelry, and other accessories. The medium initially wears a white outfit with white socks and has their face carefully made up so that when the deity descends (*Thánh giáng*), their appearance appears radiant and transformed.

In Đà Nẵng, by contrast, ritual attendants are only responsible for presenting items such as ritual scarves, betel, areca nuts, alcohol, tobacco, and petitions; they do not assist with changing the medium's costumes. After completing each incarnation, the medium retreats backstage to change into a different costume before returning to perform the next incarnation (In-depth interview, medium G., Đà Nẵng, 22 July 2022).

Ritual Musicians (*Cung văn*)

Cung văn* are ritual musicians who lead the musical performance, "specializing in instrumental accompaniment and ritual chanting (*hát văn chầu*) according to specific melodic modes and formal structures, ensuring close coordination with the spirit medium" (Ngô Đức Thịnh, 2009, *Đạo Mẫu Việt Nam*, vol. 1, Religious Publishing House, Hanoi, p. 142). *Hát văn* possesses distinctive melodic structures, yet incorporates elements from various forms of Vietnamese folk music such as *ca trù*, *trống quân*, *quan họ*, and *cải lương*. The chanting performed during palace-opening rituals in Northern Vietnam and in Đà Nẵng differs due to the regional variations discussed above.

In Northern Vietnam, *cung văn* first perform the *Văn Công Đồng* chant, followed by the *Văn Tam Tòa Thánh Mẫu*, which includes verses such as: "On an auspicious day, a serene feast is opened,Inviting the gathered Immortals and Saints to the ritual altar.Respectfully inviting the First Celestial Deity,And the Second Princess to naturally descend.Phủ Dầy, Văn Cát village,Nghĩa Hưng, Thiên Bản, the Lê lineage transformed into Trần." (Ngô Đức Thịnh, 2009, *Đạo Mẫu Việt Nam*, vol. 2, Religious Publishing House, Hanoi, p. 114)

In Đà Nẵng, *cung văn* begin with the *Hội Đồng Văn*, followed by chants recounting the sacred biography of Thiên Y Thánh Mẫu, including verses such as:

"For a thousand autumns, blue waters and green mountains endure,

Raising the sacred banner, manifesting divine power

From ancient times, the two words 'sacred deity' have remained,

Emerging from the mother's womb, guided first by filial devotion.

The ancient saint's grace is complete and profound,

From the Southern heavens to the Northern seas, the echoes still resound."

(Ngô Đức Thịnh, 2009, *Đạo Mẫu Việt Nam*, vol. 2, Religious Publishing House, Hanoi, p. 467)

The ritual chants in Đà Nẵng focus primarily on two themes: the supernatural power of the deity and the deity's travels throughout the world to save and liberate humanity. While Northern Vietnamese *chầu văn* emphasizes the origins and genealogies of the deities, *chầu văn* in Đà Nẵng concentrates instead on their appearance, demeanor, and miraculous abilities.

3. Conclusion

The ritual of *trình đồng* and *mở phủ* (presenting oneself as a medium and opening the palaces) is regarded as the most supreme ceremonial rite within the Vietnamese Mother Goddess worship tradition. It represents a formal affirmation of the bond between the spirit medium (*thanh đồng*) and the Holy Mothers. From this point onward, the medium vows to become a "child of the Saints," dedicating themselves to prayers for national peace and prosperity and to living a life that harmonizes ethical conduct with spiritual devotion.

Upon completing the rites of opening the Four Palaces—symbolized by the opening of the four jars and the peeling of the four eggs—the medium is officially recognized as a *tân đồng* (newly initiated medium). After the palace-opening ceremony, the *tân đồng* follows their master in a period of disciplined cultivation and practice, performing ritual duties according to proper norms, upholding the moral codes of the sacred tradition, and maintaining a life that is both socially virtuous and spiritually meaningful. Following a probationary period of three years of service and nine years of mediumship training, the medium advances to a major ritual within the Four Palaces tradition: the grand altar ceremony of thanksgiving to the Buddhas and deities, expressing gratitude to one's master, and receiving formal consecration (*cấp sắc*) as a fully recognized medium. Thereafter, qualified mediums may undertake religious practice independently, establish ritual altars, open palaces, and accept disciples.

Through this process, the aesthetic, ethical, and spiritual values of the palace-opening ritual within spirit possession practices become evident. While there are notable differences between Northern Vietnam and Đà Nẵng, as discussed above, the overarching purpose of the palace-opening ritual remains consistent: to pray for favorable weather, social harmony, and national peace and stability. This shared aspiration constitutes a fundamental and enduring beauty of the Vietnamese Mother Goddess worship tradition.

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Keywords: *Mother Goddess worship, goddess worship, mother goddess, three - four palaces, Da Nang.*

Economic Sciences

STRUCTURAL TRANSFORMATION OF REGIONAL ECONOMIES UNDER LONG-TERM CONSTRAINTS: INVESTMENT, EMPLOYMENT, AND PRODUCTIVITY TRENDS

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1. Introduction

Regional economies operate within a complex framework of long-term constraints shaped by demographic change, capital availability, institutional capacity, and external economic pressures. These constraints influence the pace and direction of structural transformation, defined as the reallocation of resources among sectors with differing productivity levels and growth potential. In regions facing persistent limitations, structural transformation becomes both a necessity and a challenge, requiring coordinated adjustments in investment patterns, employment structures, and productivity dynamics.

Unlike short-term cyclical fluctuations, long-term constraints exert continuous pressure on regional development trajectories. Capital scarcity, labor outmigration, and infrastructural deficits reduce adaptive capacity and amplify vulnerability to external shocks. At the same time, regions retain endogenous potential that can be mobilized through effective structural adjustment. Understanding how investment, employment, and productivity interact under such conditions is essential for designing policies that support sustainable regional development.

2. Long-Term Constraints in Regional Economic Development

Long-term constraints shape regional economies by limiting access to critical development resources. Capital constraints restrict modernization and innovation, while labor market constraints reduce human capital availability and flexibility. Institutional constraints, including regulatory fragmentation and limited administrative capacity, further complicate adjustment processes.

Demographic trends represent a particularly significant constraint. Population aging and labor outmigration alter workforce composition and reduce the supply of skilled labor. These changes affect both investment attractiveness and sectoral competitiveness. Regions experiencing sustained demographic decline often face a narrowing economic base and reduced fiscal capacity.

External economic conditions also impose constraints. Exposure to global market volatility and trade disruptions affects export-oriented regions disproportionately. Without diversified economic structures, such regions struggle to absorb shocks and maintain stable growth.

3. Investment dynamics under structural constraints

Investment plays a central role in driving structural transformation. Under long-term constraints, however, investment behavior tends to become conservative and risk-averse. Firms prioritize short-term survival and cost control over long-term expansion and innovation. As a result, investment flows concentrate in low-risk activities rather than productivity-enhancing modernization.

Public investment partially compensates for private sector limitations but is often constrained by fiscal pressures. Infrastructure projects and targeted development programs can stimulate structural change, yet their effectiveness depends on institutional coordination and strategic focus. Fragmented investment initiatives may fail to generate sustainable transformation.

Table 1 summarizes dominant investment patterns observed in constrained regional economies.

Table 1. Investment Patterns in Regions Under Long-Term Constraints

Investment Dimension	Dominant Trend	Structural Implication
Investment horizon	Short-term orientation	Limited capital deepening
Sectoral allocation	Preference for traditional sectors	Slow structural upgrading
Innovation investment	Low and selective	Weak productivity growth
Public–private balance	Increased reliance on public funding	Fiscal pressure and coordination challenges

4. Employment Structure and Labor Market Adjustment

Employment dynamics reflect both structural constraints and adaptive responses. In regions with limited investment and declining populations, employment shifts toward low-productivity sectors, often characterized by informal or precarious work arrangements. Such shifts reduce average labor productivity and constrain income growth.

Labor mobility plays a dual role. While mobility enables workers to seek better opportunities, excessive outmigration depletes regional human capital. Remaining labor forces may exhibit skill mismatches relative to emerging sectoral needs. These mismatches slow structural adjustment and reduce the effectiveness of investment initiatives.

Active labor market policies support adjustment by facilitating reskilling and mobility within regions. Education and training systems aligned with regional development strategies enhance labor adaptability and contribute to structural efficiency.

Table 2 presents key employment structure changes under long-term constraints.

Table 2. Employment Structure Changes in Constrained Regional Economies

Employment Aspect	Observed Change	Economic Effect
Sectoral employment	Shift toward services and informal work	Lower average productivity
Workforce age structure	Aging labor force	Reduced adaptability
Skill composition	Skill mismatches	Slower structural transition
Employment stability	Increased precariousness	Income volatility

5. Productivity Trends and Structural Efficiency

Productivity growth represents the primary long-term source of regional income convergence. Under structural constraints, productivity trends are shaped by both sectoral composition and firm-level efficiency. Regions dominated by low-productivity sectors experience slower aggregate productivity growth, even when individual firms improve performance.

Structural efficiency refers to the alignment of resource allocation with productivity potential. In constrained regions, structural inefficiencies persist due to limited investment, labor rigidity, and institutional barriers. Improving structural efficiency requires reallocating resources toward higher value-added activities and supporting firm-level upgrading.

Productivity heterogeneity across firms creates opportunities for reallocation-driven growth. However, without supportive institutions, market selection mechanisms may be insufficient to drive meaningful transformation.

Table 3 illustrates the relationship between structural factors and productivity outcomes.

Table 3. Structural Factors Influencing Regional Productivity Trends

Structural Factor	Impact on Productivity	Long-Term Outcome
Sectoral concentration	Limits diversification	Slower growth
Capital intensity	Constrained by investment scarcity	Reduced efficiency gains
Human capital quality	Uneven and declining	Productivity stagnation
Institutional coordination	Weak integration	Missed transformation opportunities

6. Interdependence of Investment, Employment, and Productivity

Investment, employment, and productivity interact in reinforcing cycles. Limited investment constrains modernization, leading to low productivity and restricted wage growth. In turn, weak employment prospects accelerate labor outmigration, further reducing investment attractiveness. Breaking this cycle requires coordinated intervention across all three dimensions.

Targeted investment in productivity-enhancing sectors can generate positive spillovers. Higher productivity supports wage growth and improves employment quality, stabilizing labor markets. These effects strengthen regional demand and reinforce investment incentives.

Institutional alignment is essential for coordination. Policies addressing investment, labor markets, and productivity in isolation often fail to produce sustained structural change.

7. Policy Instruments for Structural Transformation

Effective policy responses to long-term constraints prioritize adaptability and coherence. Rather than preserving existing structures, policies should facilitate transition toward more productive and resilient economic activities. Strategic investment support, labor market flexibility, and innovation incentives form the core policy toolkit.

Table 4 summarizes key policy instruments supporting structural transformation.

Table 4. Policy Instruments for Regional Structural Transformation

Policy Area	Objective	Expected Impact
Investment support	Stimulate modernization	Capital deepening
Labor market policy	Improve mobility and reskilling	Faster adjustment
Innovation incentives	Encourage productivity growth	Structural upgrading
Institutional reform	Enhance coordination	Sustainable transformation

8. Conclusion

Structural transformation of regional economies under long-term constraints represents a complex and multifaceted process. Investment limitations, labor market challenges, and productivity disparities interact to shape development trajectories. While constraints slow adjustment, they also highlight the importance of strategic coordination and institutional effectiveness.

Sustainable regional development requires policies that integrate investment stimulation, labor market adaptability, and productivity enhancement. Regions that successfully align these dimensions can transform constraints into catalysts for modernization. Structural efficiency and productivity growth thus emerge as central pillars of economic resilience and long-term regional competitiveness.

Keywords: *Regional development; Structural transformation; Investment dynamics; Employment structure; Productivity trends; Economic resilience*

Medical Sciences

EARLY FUNCTIONAL MARKERS OF METABOLIC RISK IN ADULT POPULATIONS: CLINICAL ASSESSMENT AND PREVENTIVE PERSPECTIVES

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Metabolic disorders represent a growing challenge for public health systems, largely due to their progressive nature and strong association with lifestyle and environmental factors. Conditions such as impaired glucose regulation, dyslipidemia, and central obesity often develop gradually and remain clinically silent for extended periods. By the time overt disease becomes apparent, metabolic dysfunction may already be advanced, limiting the effectiveness of therapeutic interventions. Early identification of metabolic risk is therefore a central objective of preventive medicine.

In adult populations, metabolic risk is not defined solely by the presence of diagnosed disease but by a constellation of functional changes that precede clinical thresholds. These early functional markers reflect subtle alterations in metabolic regulation, vascular responsiveness, and body composition. Detecting and interpreting such markers enables timely preventive strategies aimed at halting or reversing disease progression. This thesis examines early functional markers of metabolic risk, their clinical assessment, and their role in preventive healthcare strategies.

Metabolic risk refers to the probability of developing metabolic disorders based on physiological, behavioral, and environmental factors. Functional markers represent measurable indicators of early metabolic imbalance that do not yet meet diagnostic criteria for disease. These markers provide insight into regulatory processes rather than structural pathology.

Functional markers include deviations in fasting glucose levels within high-normal ranges, altered lipid profiles, increased waist circumference, and reduced insulin sensitivity. Unlike overt disease markers, functional indicators are often reversible through lifestyle modification and early intervention. Their identification requires careful clinical assessment and interpretation within individual patient contexts.

The concept of functional markers emphasizes prevention over treatment. By focusing on early changes, healthcare providers can shift attention toward maintaining metabolic health rather than managing established disease.

Early metabolic dysfunction arises from complex interactions between energy intake, energy expenditure, and regulatory mechanisms. Excess caloric intake and reduced physical activity disrupt energy balance, leading to adipose tissue expansion and altered metabolic signaling. Visceral fat accumulation plays a particularly significant role by releasing bioactive substances that influence insulin sensitivity and inflammatory pathways.

Insulin resistance represents a central mechanism linking early metabolic changes to disease progression. Initially, compensatory mechanisms maintain normoglycemia despite reduced insulin sensitivity. Over time, these mechanisms become insufficient, leading to impaired glucose regulation. Functional markers capture this transitional phase before irreversible damage occurs.

Low-grade systemic inflammation also contributes to early metabolic risk. Inflammatory mediators interfere with insulin signaling and lipid metabolism, amplifying metabolic imbalance. These processes often develop silently, reinforcing the importance of early detection.

Clinical assessment of metabolic risk relies on a combination of anthropometric measurements, biochemical indicators, and functional evaluation. Anthropometric measures such as body mass index and waist circumference provide accessible information on body composition and fat distribution. Waist circumference is particularly valuable as an indicator of central adiposity and associated metabolic risk.

Biochemical assessment focuses on fasting glucose, lipid profiles, and markers of insulin sensitivity. Values within high-normal ranges may signal early dysfunction when interpreted in conjunction with other indicators. Functional assessment includes evaluation of blood pressure responses, physical fitness, and lifestyle factors that influence metabolic regulation.

Table 1 summarizes key early functional markers and their clinical relevance.

Table 1. Early functional markers of metabolic risk and clinical interpretation

Functional Marker	Observed Change	Preventive Significance
Fasting glucose	High-normal values	Early glucose regulation impairment
Waist circumference	Increased central adiposity	Elevated cardiometabolic risk
Lipid profile	Borderline dyslipidemia	Atherogenic tendency
Blood pressure	High-normal range	Vascular stress indicator
Physical fitness indicators	Reduced functional capacity	Decreased metabolic adaptability

Risk stratification integrates functional markers with demographic and behavioral factors to estimate overall metabolic risk. Age, family history, physical activity level, and dietary patterns influence the interpretation of functional indicators. A comprehensive approach enables personalized preventive strategies rather than generalized recommendations.

Preventive planning focuses on modifying risk factors identified during assessment. Lifestyle interventions represent the primary strategy for addressing early metabolic risk. Dietary adjustments, increased physical activity, and behavioral changes target underlying mechanisms of metabolic imbalance.

Monitoring functional markers over time supports evaluation of intervention effectiveness. Improvements in markers indicate successful risk reduction, while deterioration signals the need for intensified preventive measures.

Lifestyle modification is the cornerstone of preventive

strategies for metabolic risk. Balanced dietary patterns support metabolic regulation by improving insulin sensitivity and lipid metabolism. Regular physical activity enhances glucose uptake and energy expenditure, contributing to metabolic stability.

Behavioral factors, including stress management and sleep quality, influence metabolic health. Chronic stress and sleep deprivation disrupt hormonal regulation, increasing metabolic risk. Addressing these factors complements dietary and physical activity interventions.

Patient engagement is essential for sustained lifestyle modification. Education and counseling enhance understanding of the relationship between functional markers and long-term health outcomes, promoting adherence to preventive recommendations.

Preventive healthcare systems play a crucial role in identifying and managing early metabolic risk. Primary care settings provide opportunities for routine assessment and early intervention. Integrating functional marker evaluation into standard health examinations enhances preventive capacity.

Population-level prevention strategies complement individual interventions by promoting environments that support healthy behaviors. Public health initiatives aimed at improving nutrition, physical activity, and stress reduction contribute to metabolic health across adult populations.

Early functional markers of metabolic risk offer valuable insight into the transitional phase between metabolic health and overt disease. Their identification enables timely preventive interventions that can significantly reduce the burden of metabolic disorders. Clinical assessment integrating anthropometric, biochemical, and functional indicators supports personalized risk stratification and effective preventive planning.

By emphasizing early detection and lifestyle modification, preventive medicine can shift the focus from disease management to health preservation. Strengthening preventive approaches within healthcare systems is essential for addressing the growing prevalence of metabolic risk in adult populations and improving long-term health outcomes.

Keywords: *Metabolic risk; Preventive medicine; Functional markers; Early detection; Adult health; Metabolic regulation*

Pedagogical Sciences

EDUCATIONAL MOTIVATION AS A BASIS FOR ACADEMIC ENGAGEMENT IN HIGHER EDUCATION STUDENTS

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Educational motivation constitutes one of the central determinants of academic engagement in higher education and plays a decisive role in shaping students' learning behavior, persistence, and academic achievement. In contemporary educational contexts, where students are expected to assume greater responsibility for their learning trajectories, motivation serves as the internal driving force that transforms institutional requirements into meaningful personal goals. Without sufficient motivational foundations, even well-designed curricula and advanced instructional methods fail to produce sustainable educational outcomes.

Academic engagement is a multidimensional construct encompassing cognitive, emotional, and behavioral components. Motivated students demonstrate sustained attention, active participation, and willingness to invest effort in learning activities. Educational motivation provides the psychological energy that sustains these forms of engagement over time. It influences how students interpret learning tasks, respond to challenges, and persist in the face of difficulty. In higher education, where learning demands are complex and self-directed, motivation becomes particularly critical.

The formation of educational motivation is shaped by a combination of personal, social, and institutional factors. Students enter higher education with diverse motivational profiles influenced by prior educational experiences, family expectations, and personal aspirations. These initial orientations are further shaped by the learning environment, instructional practices, and assessment systems encountered at the university level. Educational motivation thus emerges as a dynamic process rather than a fixed trait.

Intrinsic motivation plays a central role in sustaining deep academic engagement. When students perceive learning activities as meaningful, relevant, and aligned with personal interests, they are more likely to engage cognitively and emotionally. Intrinsic motivation supports curiosity, critical thinking, and autonomous learning behavior. In contrast, extrinsic motivation, while effective in promoting short-term compliance, may not support long-term engagement if not integrated with internal goals.

Academic engagement is closely linked to students' perceptions of competence and autonomy. Students who believe they are capable of mastering academic tasks demonstrate higher levels of engagement and persistence. Perceived autonomy enhances motivation by allowing students to make choices and exercise control over learning processes. Educational environments that support autonomy and competence contribute to the internalization of academic goals.

The role of educators in shaping educational motivation cannot be overstated. Teaching practices that emphasize clarity, relevance, and constructive feedback foster motivation by helping students understand the purpose and value of learning activities. When instructors communicate high expectations combined with supportive guidance, students are more likely to adopt mastery-oriented goals. Respectful and responsive interaction between educators and students strengthens motivation and engagement.

Assessment practices significantly influence educational motivation. Evaluation systems focused solely on performance outcomes may encourage surface learning and anxiety-driven engagement. In contrast, assessment approaches that emphasize formative feedback, progress monitoring, and reflection support intrinsic motivation and deeper engagement. Transparent criteria and opportunities for self-assessment help students connect effort with improvement, reinforcing motivational processes.

Social context also shapes motivation and engagement. Peer interaction provides opportunities for collaborative learning, social comparison, and mutual support. Positive peer environments enhance motivation by fostering a sense of belonging and shared purpose. Conversely, competitive or exclusionary climates may undermine motivation and disengage vulnerable students. Educational motivation is therefore embedded within the social fabric of the learning environment.

The transition to higher education often presents motivational challenges. Increased academic demands, reduced external structure, and unfamiliar expectations require students to adapt motivational strategies. Some students experience motivational decline during this transition, particularly if institutional support is insufficient. Orientation programs, mentoring, and academic advising can support motivational adjustment by clarifying expectations and reinforcing self-efficacy.

Educational motivation is also influenced by students' future-oriented goals. Perceived relevance of academic content to professional and personal aspirations strengthens engagement. When students understand how learning contributes to long-term objectives, they are more likely to invest effort and persist. Linking academic content to real-world applications enhances motivational relevance.

Challenges to sustaining educational motivation include academic overload, unclear expectations, and limited feedback. Institutional rigidity and lack of flexibility may further reduce motivation by restricting autonomy. Addressing these challenges requires intentional pedagogical design and institutional commitment to student-centered learning.

Motivation and engagement are mutually reinforcing. Engaged students experience success, which strengthens motivation, while motivated students are more likely to engage actively. Breaking negative cycles of low motivation and disengagement requires early intervention and supportive pedagogical strategies. Educational motivation thus functions as both a cause and consequence of academic engagement.

In conclusion, educational motivation represents a foundational element of academic engagement in higher education students. It influences how students approach learning tasks, interact with the educational environment, and persist through

challenges. By fostering intrinsic motivation, supporting autonomy and competence, and creating meaningful learning experiences, higher education institutions can enhance academic engagement and promote sustainable learning outcomes. Understanding and supporting educational motivation is therefore essential for improving educational quality and student success in contemporary higher education.

Keywords: *Educational motivation; Academic engagement; Higher education; Student learning behavior; Intrinsic motivation; Pedagogical psychology*

SELF-REGULATED LEARNING SKILLS IN UNIVERSITY STUDENTS: PEDAGOGICAL FACTORS AND LEARNING OUTCOMES

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Self-regulated learning has emerged as a central concept in contemporary higher education, reflecting the growing expectation that university students assume responsibility for planning, monitoring, and evaluating their own learning processes. In contrast to teacher-directed instruction, self-regulated learning emphasizes learner autonomy, metacognitive awareness, and purposeful engagement with academic tasks. The development of self-regulated learning skills is increasingly recognized as a prerequisite for academic success, adaptability, and lifelong learning.

University students encounter learning environments characterized by increased complexity, reduced external control, and greater freedom of choice. These conditions create opportunities for autonomy but also expose deficiencies in students' ability to manage learning effectively. Many students struggle with time management, goal setting, and self-monitoring, leading to inconsistent academic performance despite adequate intellectual ability. Understanding the pedagogical factors that support self-regulated learning is therefore essential for enhancing learning outcomes in higher education.

Self-regulated learning encompasses cognitive, metacognitive, motivational, and behavioral components. Cognitive strategies involve information processing techniques such as summarization, elaboration, and organization. Metacognitive strategies include planning learning activities, monitoring comprehension, and evaluating progress. Motivational components sustain effort and persistence, while behavioral strategies relate to managing time, learning environments, and resources. Effective self-regulation requires the integration of these components rather than their isolated application.

Pedagogical design plays a decisive role in shaping students' self-regulated learning skills. Learning environments that emphasize passive reception of information provide limited opportunities for self-regulation. In contrast, instructional approaches that require active engagement, problem-solving, and reflection encourage students to plan and monitor their learning. Task design that incorporates clear objectives and opportunities for choice supports the development of regulatory skills.

Feedback constitutes a critical pedagogical factor in self-regulated learning. Constructive feedback guides students' understanding of performance quality and highlights strategies for improvement. When feedback focuses on processes rather than solely on outcomes, students are more likely to reflect on their learning strategies and adjust behavior. Regular feedback cycles reinforce self-monitoring and self-evaluation, which are core components of self-regulation.

Assessment practices influence self-regulated learning by shaping students' perceptions of success and failure. Assessment systems that emphasize formative evaluation support experimentation and reflection, whereas exclusively summative assessment may discourage strategic learning. Opportunities for self-assessment and peer assessment promote metacognitive awareness and responsibility for learning outcomes. Transparent criteria further enable students to align effort with expectations.

The role of motivation in self-regulated learning is particularly significant. Students with high levels of self-efficacy and intrinsic motivation are more likely to engage in self-regulatory behaviors. Pedagogical strategies that foster relevance, autonomy, and competence strengthen motivational foundations. When students perceive learning activities as meaningful and achievable, they are more inclined to invest effort in regulating their learning.

Social interaction within the learning environment also contributes to self-regulated learning. Collaborative learning contexts provide opportunities for shared regulation, where students observe and adopt effective strategies from peers. Discussion and group work facilitate reflection and strategy comparison, enhancing metacognitive development. However, collaboration must be structured to ensure individual accountability and engagement.

Learning outcomes associated with self-regulated learning extend beyond academic performance. Students who develop regulatory skills demonstrate improved adaptability, resilience, and problem-solving capacity. These outcomes are particularly valuable in dynamic professional environments that require continuous learning. Self-regulated learners are better equipped to transfer knowledge across contexts and manage complex tasks independently.

Challenges to fostering self-regulated learning include students' prior educational experiences, which may have emphasized external control and rote learning. Transitioning to self-regulated learning requires gradual scaffolding and explicit instruction in regulatory strategies. Educators play a key role in modeling self-regulation and guiding students through this transition.

Table 1 presents key pedagogical factors influencing self-regulated learning and associated learning outcomes.

Pedagogical factor	Contribution to self-regulation	Learning outcome effect
Active task design	Encourages planning and monitoring	Deeper understanding
Formative feedback	Supports self-evaluation	Improved academic performance
Transparent assessment	Aligns effort with expectations	Strategic learning behavior
Autonomy-supportive teaching	Enhances motivation and persistence	Sustained engagement
Collaborative learning	Facilitates shared regulation	Transferable learning skills

The development of self-regulated learning skills requires institutional commitment. Curricula that integrate opportunities for reflection, goal setting, and feedback across courses support cumulative skill development. Professional development for educators enhances their capacity to design learning environments conducive to self-regulation.

Digital learning environments present both opportunities and challenges for self-regulated learning. While online platforms offer flexibility and access to resources, they also demand high levels of self-discipline and time management. Pedagogical

support in digital contexts must therefore emphasize regulatory skills to prevent disengagement.

In conclusion, self-regulated learning skills represent a critical foundation for academic success and lifelong learning in higher education. Pedagogical factors such as task design, feedback, assessment practices, and motivational support significantly influence the development of these skills. By intentionally fostering self-regulated learning, educators enhance not only academic outcomes but also students' capacity for independent and adaptive learning. Strengthening self-regulation within higher education thus contributes to both educational quality and long-term individual development.

Keywords: *Self-regulated learning; Higher education; Pedagogical design; Learning outcomes; Student autonomy; Metacognition*

PEDAGOGICAL SUPPORT FOR THE DEVELOPMENT OF CRITICAL THINKING IN CONTEMPORARY HIGHER EDUCATION

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The development of critical thinking has become a central objective of contemporary higher education as societies increasingly demand graduates capable of analytical reasoning, independent judgment, and responsible decision-making. In an educational environment characterized by information overload, rapid knowledge renewal, and complex social challenges, the ability to critically evaluate information is essential. Pedagogical support plays a decisive role in cultivating critical thinking by creating conditions that encourage reflection, inquiry, and intellectual autonomy.

Higher education institutions face the challenge of transitioning from knowledge transmission models toward learning environments that promote active engagement with content. Critical thinking does not emerge automatically from exposure to information; it requires intentional pedagogical design and sustained support. Understanding how pedagogical support mechanisms influence the development of critical thinking is therefore crucial for improving educational outcomes.

Critical thinking is commonly understood as the ability to analyze, evaluate, and synthesize information in a reasoned and reflective manner. It involves questioning assumptions, assessing evidence, and considering alternative perspectives. In educational contexts, critical thinking supports deeper learning and enables students to apply knowledge flexibly across contexts.

Critical thinking encompasses cognitive skills such as analysis and evaluation, as well as dispositions including openness, skepticism, and intellectual humility. Pedagogical support must address both dimensions by providing opportunities for practice and fostering an environment that values inquiry and reflection.

Pedagogical support refers to intentional instructional actions and conditions designed to facilitate student development. In the context of critical thinking, support includes guidance, feedback, and scaffolding that encourage students to engage actively with learning tasks.

Educators act as facilitators rather than sole sources of knowledge, guiding students through processes of inquiry and reflection. Supportive pedagogical practices help students navigate complex tasks and gradually assume greater responsibility for their learning. This approach aligns with learner-centered education principles and supports critical thinking development.

Instructional strategies significantly influence students' critical thinking abilities. Problem-based learning, case analysis, and inquiry-oriented tasks require students to analyze situations, evaluate evidence, and propose solutions. These strategies shift the focus from memorization to reasoning and application.

Questioning techniques are particularly effective in promoting critical thinking. Open-ended questions encourage exploration and justification of ideas, while reflective prompts support metacognitive awareness. When instructors model critical inquiry, students are more likely to adopt similar approaches.

Collaborative learning also contributes to critical thinking by exposing students to diverse perspectives. Structured discussion and debate challenge assumptions and stimulate deeper analysis. Pedagogical support ensures that collaboration remains purposeful and focused on reasoning rather than consensus alone.

The learning environment plays a vital role in supporting critical thinking. Environments that promote psychological safety enable students to express ideas without fear of judgment. Such environments encourage experimentation and learning from mistakes, which are essential for intellectual growth.

Institutional culture influences how critical thinking is valued and practiced. When critical inquiry is recognized and rewarded, students are more likely to engage in reflective learning. Pedagogical support extends beyond individual courses to include curriculum design and institutional policies.

Assessment practices significantly affect the development of critical thinking. Evaluations focused solely on factual recall may discourage analytical engagement. In contrast, assessments that emphasize reasoning, argumentation, and reflection support critical thinking development.

Feedback is a key component of pedagogical support. Constructive feedback that addresses reasoning processes helps students understand how to improve their thinking. Timely and specific feedback reinforces reflective practices and guides students toward higher levels of cognitive engagement.

Several challenges complicate the implementation of pedagogical support for critical thinking. Large class sizes and limited instructional time constrain individualized guidance. Students' prior educational experiences may also limit readiness for critical inquiry.

Resistance to change among educators and institutional constraints may further hinder adoption of supportive pedagogical practices. Addressing these challenges requires professional development and institutional commitment to pedagogical innovation.

Pedagogical support is a fundamental factor in the development of critical thinking in contemporary higher education. Through intentional instructional strategies, supportive learning environments, and reflective assessment practices, educators can foster students' capacity for analysis, evaluation, and independent judgment.

The cultivation of critical thinking equips students with skills essential for academic success and societal participation. By prioritizing pedagogical support for critical thinking, higher education institutions contribute to the development of reflective, responsible, and adaptable graduates capable of navigating complex challenges.

Keywords: *Critical thinking; Pedagogical support; Higher education; Instructional strategies; Reflective learning; Educational methodology*

Philosophical Sciences

ARTIFICIAL INTELLIGENCE AND MAN: COMPARATIVE CHRISTIAN ANTHROPOLOGY IN THE DOCUMENT *ANTIQUA ET NOVA*

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Introduction

Artificial Intelligence (AI) is a specific symbol of the information society of the late moderna. Its emergence and its constant progressive connection with Information and Communication Technologies (ICT) are already being described as revolutionary events and are compared to key historical inventions that represented crucial epochal turning points (printing or the steam engine). Since the new developments that AI is achieving are so significant that they touch all aspects of human existence, and that they fundamentally change human knowledge, communication with others, but also with the environment, as well as the modalities of work, approach to culture and understanding of art, the new phenomenon has been the central reality of multidisciplinary scientific analysis since its beginning. This paper tends to offer a kind of introduction to the Christian (Catholic and Orthodox) assumptions of this challenge, which in its concrete form has never been found in the history of the Church and its theology, but in a deep ontological vision it can be perceived in some earlier phenomena, which today need to be creatively reinterpreted.

In order to limit and concretize such a broadly stated research intention, we will present and analyse one important and modern document of the magisterium of the Catholic Church, *Antiqua et nova*, published in January 2025[1]. This official church commentary refers directly enough and with good arguments to the firm positions of Roman Catholic theology on the phenomenon we are dealing with. As such, avoiding evasiveness and ambiguities, this text becomes the guide for all further written works of Roman Catholic theologians in the extremely challenging sphere of the relationship between theology and science.

The Most Important General Insights

- Positive and dialogical approach to scientific achievements

The AN is one of the rare documents of the Dicastery for the Doctrine of the Faith which aim is not to warn against dogmatic errors, to correct them by an official act, to express forms of opinion on certain topics, or to react strictly to the wrong directions of contemporary civilization. This document does not, therefore, have that restrictive character, which underlies a large number of similar notes, issued in the last few decades. Instead, readers are presented with a text that aims to define AI and indicate the use of this tool, so that it too may be included in civilizational progress, with respect for the dignity of the person and the common good. Thus, Catholic theology, in continuity with the Second Vatican Council, offers one global *positive vision of technology and science*. These innovations in science are an integral part of human intelligence, and the Church encourages scientists, artists, and cultural workers to further explore them, provided that this gift of God is used correctly and wisely. The correct use of AI by man means its orientation towards brotherhood, justice, and dignity, and concerns not only the Church or church people, but the entire human race.

- Embodied intelligence as an assumption of humanity

The issue of AI did not confine the perspective of the author of AN to some spiritual problem setting. On the contrary, the authors insist that one of the key shortcomings of AI is that it does not have a body, that it is disembodied, it does not have a true material manifestation. This is both an important and very positive point of this note. Incorporeal entities are not concrete, they are not real, because they are not in a real relationship with other entities. Man is called to the risk of encountering the other, with the challenging physical presence, to a face-to-face encounter, or, in the words of Pope Francis, "body to body (corpo a corpo)"[2]. As there is no incorporeal Christ, so there are no interpersonal relationships that do not go through a concrete bodily encounter, a greeting, a handshake, a hug, a kiss. Screens, video calls, robots or holograms can never replace this, because they cannot be a substitute for sharing joy or sorrow and sacrificing for a loved one. Even if they reach an exceptional level of intelligence, if the threshold of imitating a human is astonishingly raised, AI will not be a personal being, but will still remain an instrument, a tool in the hands of human persons.

Synthetic Insights: AN in the Perspective of Comparative Theology: Special Attention to Comparative Christian Anthropology

The constant assumption of Roman Catholic (but also of Orthodox) anthropology is that the identity and vocation of man are illuminated only in the mystery of the incarnate Son of God, the Lord Jesus Christ[3]. Christology is, therefore, the optics through which anthropology is viewed. The basic document of the Catholic Church, its *Catechism*, for the purpose of clarifying and confirming this position, quotes the following words of St Peter Chrysologus (5th century), which in sublime way summarize the Christological and eschatological anthropology of the entire Church of Christ:

St. [the apostle] Paul tells us that the human race takes its origin from two men: Adam and Christ. ... The first Adam, the last Adam: the first had a beginning, the last knows no end. The last Adam is indeed the first; as he himself says: "I am the first and

[1] The original version in Italian, which we use in this work, is available at: https://www.vatican.va/roman_curia/congregations/cfaith/documents/rc_ddf_doc_20250128_antiqua-et-nova_it.html (1.2.2025) All quotations from this note will be marked with the abbreviation AN and the number of the paragraph to which they refer.

[2] In footnote 123, the AN document quotes these very words from the papal exhortation: Francesco, Esort. ap. *Evangelii gaudium* (November 24, 2013), no. 88: AAS 105 (2013), 1057.

[3] The Second Vatican Council is explicit: "The truth is that only in the mystery of the incarnate Word does the mystery of man take on light." (GS 22).

the last."[4]

Taking these brilliant words of a Western Father (the Metropolitan of Ravenna) and a Doctor of the Church into account, it seems very strange that the theological words about Christ are so modestly present in our document. Strictly speaking, the very *name of Christ* is largely missing from the AN, since it is literally mentioned *only twice* in the main text of the document of 117 paragraphs with 215 footnotes. When the teaching and belief that the paradigm of man is the Second, that is, the Last (novissimus) Adam is not sufficiently emphasized, when the patristic position that man is the icon of the other is not insisted on, then the essence of man, as an individual or person, begins to be sought in history as the only truth of existence and *in himself*. The AN note suffers from a Christological, but also of a Trinitarian deficit, which, as always, manifest themselves in an incomplete anthropology. The individualization of a person is evident: the icon is sought in some "part" of the human individual, which threatens the integral theology of the icon with partialization. Bearing in mind that the philosophical and theological tradition, which this document forces as crucial for defining man as a person, is reduced to the trajectory of Aristotle – Augustine – Thomas Aquinas, the conclusions are completely natural and expected. According to Augustine, for example, the man is superior to animals, because they do not have reason or mind or intelligence (ratio, vel mens, vel intellegentia)[5]. Very directly, just one sentence before this one, which AN does not quote, the saint of Hippo claims: "As for us, my dearest ones, we must remember that we are made in the image of God (ad imaginem Dei), which is nothing other than intellect (nec alibi quam in ipso intellectu)".

True, there is a certain number of statements according to which freedom is identified as an essential component of human personality. We would call these attitudes Eastern-Christian, according to their resonance and origin, nevertheless it is soon realised that AN understands human freedom as a means leading to the goal – moral perfection. Freedom is necessary for the achievement of conscientious moral responsibility of the human person (cf. AN 39). Responsibility, however, is directly connected with laws, legal assumptions and rules for the use of AI. The situation is similar with the second assumption of Orthodox anthropology, which forms an inseparable unity with freedom, which is love. It, like freedom, falls under the categories of psychological-moralistic and rational nature, that is, it is reduced to one of the many aspects of human action, and is not a *conditio sine qua non* of his being, existence. Thus, love and freedom are two of the many abilities by which man reveals himself to the world, and not a dual ontological basis of his being that is formed as a relationship, through the other, in community.

Therefore, to the Orthodox reader, it seems that in AN there are two anthropologies, one closed or static and one open, dynamic, which can otherwise be traced with the chronological and ontological boundary set by the Second Vatican Council. Contemporary Catholic anthropology is still waiting for a decisive answer to the questions: is creation complete or not, was man created perfect, and then became partially corrupted by the fall, or was he a child whom the Pedagogue leads with two Hands to the height of the growth of the eschatological Prototype?

Conclusion

A positive approach to innovations in science, as integral parts of human intelligence, and the stance of the Catholic Church to encourage scientists, artists, and cultural workers to further research and creativity, brings Western cosmology closer to Eastern ktisiology, according to which God's creation is not a *fait accompli*, which is why man is not a finished being, but rather one who is still working and awaiting his palingenesis and resurrection.

The refusal to understand man as algorithmically assessed, measured and judged clearly expresses the protest of the Catholic Church against a closed individualistic anthropology. Man is not the sum of all possible, even very precise, information about himself, because he is not a mathematical-logical machine. God did not want him to be like that. He does not live in a digital world of impersonal individuals. Yevgeny Zamyatin warned long ago that dictatorships tend to make us individuals and numbers[6]. AN also rises up against the dictatorship of reason, searching for the deepest and most personal in man. It is on the trail to find that root of humanity in freedom and love, but it seems that it does not reach the end. The presence of elements of patristic personology does not mean, at the same time, their dominance. Personality, as existence through the other, is diluted by the teaching of the individual *ratio* as *imago Dei* and in its consequences. To the specific question: whether a person can solve the problem that arises with the emergence of the AI as a thinker or as a person (understood in the Cappadocian expression, where the icon is personhood or freedom as 'autexusion'), a Western person would, through logic, ethics or the legal system, opt for the first answer, for rationality, and thus would return to the vicious circle of logic or ousiology, and in fact, death.

***Keywords**: Artificial Intelligence, Anthropology, Comparative Theology, Individual, Person*

[4] St. Peter Chrysologus, *Sermo* 117; PL 52, 520-521.

[5] Cf. Augustine of Hippo, *De Genesi ad litteram libri duodecim*, III, 20, 30: PL 34, 292. Or Augustine of Hippo, *Enarrationes in Psalmos*, 54, 3: PL 36, 629: the conclusions of human beings are very different from those of animals, because humans have intelligence.

[6] "The multiplication table is more wise and more absolute than the ancient god: for the multiplication table never (do you understand – *never*) makes mistakes! There are no more fortunate and happy people than those who live according to the correct, eternal laws of the multiplication table. No hesitation! No errors!" Yevgeny Zamyatin, *We*, A Dutton Paperback: New York, 1952, 63-64.

Technical Sciences

OPERATIONAL EFFICIENCY AND RELIABILITY OF INDUSTRIAL TECHNICAL SYSTEMS UNDER CHANGING OPERATING CONDITIONS

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Industrial technical systems operate in environments characterized by continuous change in operating conditions, including fluctuations in load, variable demand, environmental influences, and gradual component degradation. These factors place increasing demands on system efficiency and reliability, which together determine the economic and functional performance of industrial operations. Operational efficiency reflects the ability of a system to achieve desired outputs with minimal resource consumption, while reliability represents the capacity to perform intended functions consistently over time without failure. In practice, these two attributes are closely interconnected and must be addressed simultaneously.

Changing operating conditions challenge traditional engineering approaches that assume stable regimes and predictable system behavior. As industrial systems become more complex and integrated, their sensitivity to disturbances increases. Ensuring both efficiency and reliability under such conditions requires adaptive operational strategies, continuous monitoring, and coordinated system management. This thesis examines key factors influencing operational efficiency and reliability of industrial technical systems operating under changing conditions and explores engineering approaches that support sustainable system performance.

Changing operating conditions arise from both internal and external sources. Internally, production scheduling, equipment aging, and maintenance activities alter system behavior. Externally, variations in demand, supply chain disruptions, and environmental factors introduce additional uncertainty. These changes affect load profiles, thermal regimes, and mechanical stress distribution across system components.

Variability in operating conditions increases the likelihood of transient states that deviate from nominal performance. During such transitions, systems may experience efficiency losses and elevated failure risk. Engineering analysis must therefore focus on understanding how systems respond to variability rather than solely optimizing steady-state performance.

Operational efficiency and reliability are often treated as separate performance dimensions, yet they are intrinsically linked. High efficiency achieved through aggressive operating regimes may increase component stress and accelerate degradation, reducing reliability. Conversely, overly conservative operation may enhance reliability but reduce efficiency and economic viability.

Balancing efficiency and reliability requires identifying optimal operating zones that maximize output while maintaining acceptable stress levels. This balance is dynamic, shifting as operating conditions change and components age. Engineering approaches must therefore incorporate mechanisms for continuous adjustment rather than fixed optimization targets.

Reliability-oriented efficiency emphasizes sustainable performance over short-term gains. By integrating reliability considerations into efficiency optimization, systems can achieve stable long-term operation with reduced risk of unexpected failures.

Efficiency enhancement in industrial technical systems involves optimizing energy use, material flow, and process coordination. Energy-efficient operation reduces operating costs and thermal stress, indirectly supporting reliability. Process optimization aligns subsystem operation to minimize losses and improve throughput.

Advanced control strategies enable dynamic adjustment of operating parameters in response to changing conditions. By maintaining optimal setpoints across variable regimes, control systems support consistent efficiency. However, efficiency-focused control must be coordinated with reliability considerations to avoid excessive corrective actions that increase wear.

Reliability management addresses the ability of a system to withstand variability without failure. Under changing operating conditions, reliability depends on robust design, condition monitoring, and adaptive maintenance strategies. Components exposed to frequent load fluctuations experience accelerated fatigue, making proactive reliability management essential.

Condition-based monitoring provides real-time insight into system health, enabling early detection of degradation. Reliability-oriented operation uses this information to adjust loads, schedule maintenance, and prevent failure escalation. Such approaches reduce downtime and extend component service life.

Human factors also influence reliability. Operator awareness and adherence to procedures affect system response to changing conditions. Clear operational guidelines and decision-support tools enhance human reliability and support consistent system performance.

Integrated operational strategies combine efficiency optimization and reliability management within a unified framework. Rather than addressing these objectives independently, integrated strategies align control, monitoring, and maintenance decisions with overall system performance goals.

Load management represents a key element of integration. By smoothing load profiles and avoiding extreme operating regimes, systems reduce stress while maintaining acceptable efficiency. Operational planning that anticipates variability further enhances system resilience.

Table 1. Factors Influencing Operational Efficiency and Reliability in Industrial Technical Systems

Factor	Influence on Efficiency	Influence on Reliability
Load variability	Reduces process stability	Increases component fatigue
Control strategy	Maintains optimal performance	Prevents instability and overload
Condition monitoring	Identifies inefficiencies	Enables early fault detection
Maintenance planning	Minimizes downtime	Extends component service life
Operator interaction	Supports adaptive operation	Reduces human-induced errors

Operational efficiency and reliability directly influence economic outcomes. Efficient systems consume fewer resources, while reliable systems reduce downtime and maintenance costs. Under changing operating conditions, integrated management approaches deliver superior economic performance by preventing costly failures and maintaining stable output.

Investment in monitoring and adaptive control yields long-term benefits through improved availability and predictability. Lifecycle-oriented evaluation demonstrates that reliability-oriented efficiency optimization reduces total cost of ownership, even if initial implementation costs are higher.

As industrial systems continue to evolve, the importance of managing efficiency and reliability under variable conditions will increase. Future engineering approaches will emphasize adaptability, resilience, and system-level integration. Continuous improvement of monitoring, control, and operational planning capabilities will support sustainable industrial performance.

Education and professional training must also evolve to equip engineers and operators with the skills necessary to manage complex systems dynamically. Interdisciplinary perspectives that integrate mechanical, electrical, and organizational considerations will define best practices.

Operational efficiency and reliability are fundamental performance attributes of industrial technical systems operating under changing conditions. Variability in loads, environments, and system states introduces challenges that cannot be addressed through static optimization alone. Integrated engineering approaches that balance efficiency and reliability provide a robust foundation for sustainable operation.

By combining adaptive control, condition monitoring, reliability-oriented maintenance, and coordinated operational planning, industrial systems can maintain high performance while mitigating the risks associated with variability. Treating efficiency and reliability as interdependent objectives enables systems to adapt to change without sacrificing stability or economic viability.

Keywords: *Industrial technical systems; Operational efficiency; Reliability management; Changing operating conditions; Integrated engineering; System performance*

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